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THE

SEWERAGE SYSTEM

OF

VICTORIA, BRITISH COLUMBIA.

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To the Ratepayers of the City of Victoria.

In view of the very necessary and important sewerage works now being carried out in this City, and the imperative necessity for their extension, the Sewerage Commissioners desire to submit for your consideration, the accompanying short paper, descriptive of the principles upon which the system is founded. The work has, owing to the immense quantity of rock encountered, proved hitherto expensive; but the most difficult and most costly part has been performed, and a sufficient sum has been retained to complete the outlet works and main sewers, the latter of which aggregate 22,667 feet in length. The Commissioners trust, that the portion of the system on which work has been performed will be ready for use by July, and cordially invite any ratepayer, who is desirous of obtaining any information, either as to what has been done, or as to what is proposed to be done, to visit the engineer's office, in the City Hall.

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THE SEWERAGE SYSTEM

—OF—

VICTORIA, B. C.,

—BY—

EDWARD MOHUN,

M. Can. Soc. C. E., M. Am. Soc. C. E., Etc.

Since in spite of the exhaustive manner in which the question of the sewerage of this City has been discussed in the newspapers during the past five or six years, there appears to be a doubt in the minds of some of our citizens, as to the efficiency of the "separate system," a few facts in relation thereto deserve the earnest attention of those who have the true interest of the city at heart.

Sewage may be classified roughly under three heads, viz., 1st, The fluid and feculant refuse of dwellings which is carried by the agency of water to the outlet; 2nd, The solid matter, such as ashes, animal and vegetable refuse, old boots, and the thousand and one articles of rubbish, the proper place for deposit of which is the dust-bin, and whose ultimate destination, with the exception of the ashes, is the Crematory; 3rd, The contents of privies and earth-closets, which should be removed in air-tight carts to the Crematory and there burnt with the rest of the garbage.

It is with the first of these divisions that it is proposed to deal under the general head of sewage.

It will hardly be disputed that an efficient system of sewerage is essential to the prosperity of any city, and the health and comfort of its inhabitants.

A certain class of diseases, known as "pythogenic," will inevitably appear sooner or later in any populated district, in which the laws of hygiene are disregarded. Among these to select one of the most typical, typhoid fever is considered to entirely arise from the violation of those laws.

Pure air, pure water, and a pure soil are essential to health. Neither the first nor second of these can be obtained from a soil saturated with filth. Pure water may be conveyed from a distance, but the emanations from a foul soil will contaminate the air. In order to maintain our soil in a state of purity, it is essential that all animal and vegetable refuse of every description should be removed with all conceivable rapidity to a distance from our dwellings.

Admitting the necessity of sewerage, the question arises as to the system which promises to be the most efficient, and as a secondary consideration the least costly. Here we may profit by the dearly bought experience of others, and while adopting only such measures as have stood the test of actual practice, may avoid those to which partial or entire failure has been traced.

Leaving out of the question the "Pneumatic System," which, though claimed by its inventor, Capt. T. Liernur, as the system of the future, is too costly, and perhaps too experimental to be ventured upon here; and also setting on one side the utilization of the sewage, as involving a heavy additional expenditure with no commensurate advantages; it will be generally admitted that our sewage must be carried to the sea, and discharged at a point distant enough from the mouth of the Harbor to ensure its effective and inoffensive distribution in the Straits.

Having determined upon carrying our sewage by the agency of water to the sea, the first point naturally arising is whether the combined or the separate system should be adopted. This question the ratepayers have most emphatically decided in favor of the latter.

There are many however who fail to clearly distinguish between the two systems, and it has been frequently stated that the pipes used are too small to carry the surface water as well as the sewage. The answer to this statement is obvious, under the "separate system," the surface water is separated from the sewage.

Were the former to be admitted to the sewers, not only would provision have to be made for the carriage of the sewage but also for the immeasurably greater quantity of surface water contaminated by its contact with the sewage. Taking the system now under construction, the outlet sewer is egg-shaped, and measures 2 ft. 10 in. in its greatest width, and 4 ft. 3 in. in its greatest depth, and has a fall or 1 in 1200; when the depth of sewage is 2 ft. 10 in. or two-thirds of the depth, according to Mr. Baldwin Latham's table the discharge will be 367,569 imperial gallons an hour; when running full the same sewer will discharge 530,975 gallons an hour, running one-third full the discharge will be 110,024 gallons an hour. It is admitted that 5 gallons an hour is an adequate allowance per head for each man, woman and child in the area sewered; then provision has been made to carry the sewage of a population of 73,514; while under extraordinary circumstances 106,195 persons would be provided for. In order to show the enormous size such a sewer would have to be to carry the rainfall, let it be assumed that the area to be provided for contains 2000 acres, that the average fall of the land is 1 in 400, that the streets are partly macadamised and partly paved, and that the heaviest known rainfall has been 1½ inches in one hour, then by Mr. Burkli Ziegler's formula (Trans. Am. Soc. C. E., Nov., 1881,) Cub. feet a second reaching the sewer, $=.5 \times 1.5 \times 2000 \sqrt[4]{\frac{250}{2000}} = 892$, equivalent to $\frac{29}{100}$ of the total rainfall.

The writer has found that nearly ⅓ of a heavy rainfall will reach the outlet under favorable conditions.

Assuming that the sewer is flowing full with a velocity of 5 feet a second, its size if egg-shaped will be 12 ft. 6 in. x 18 ft. 9 in., discharging twenty million gallons an hour. It is obvious that in the absence of heavy rains, the quantity of sewage which would freely flow in the 2 ft. 10 in. x 4 ft. 3 in. sewer, would occupy in the larger one so small an area in proportion to its perimeter that a self-cleansing velocity could not be maintained, and it would become as is the case with so many of the large sewers of the combined system, a sewer of deposit and an elongated cesspool.

In support of this view, probably the most eminent authority of the century, Sir Robert Rawlinson says :—

"For main sewering the engineer may profitably consult tables of rainfall, of areas, and of the flow of water from the site, and it will be quite in order for him to do so ; but if he attempts to apportion sewers so as to be of capacity to receive and remove the flood water, six to ten or more feet below the surface, he will commit a serious and costly blunder, as heavy falls of rain cannot be dealt with in such a manner. A rule of three sum, made up of "area, rainfall and dimensions of sewers," cannot be safely acted upon. Heavy falls of rain must pass at and over the surface as during previous time, or special drains must be used if they exist, or must be provided if they do not exist, and the sewers must be confined in sub-sectional capacity so as to be equal to the removal of waste water from houses and manufactures."

Again in the Public Health Act of England, the Imperial Government lays down the following rule:—

"Main sewers must not be of capacity to contain flood water of the area drained, as such flood water should be passed over the surface, or by special channels and flood water drains."

It is perhaps not generally known that both in London and Paris, attempts have been made to keep the rainfall, or storm water, and the sewage separate.

In a letter dated 16th August, 1886, received by the writer from Sir Robert Rawlinson, speaking of the drainage of buildings covering a large area, that gentleman says: "The old sewers and drains were of large dimensions, sufficient for a man to walk through, in these large sewers, pipes of cast iron are laid from 4 in. in diameter to 9 in. in the outlet." Again, "The vice-regal residence in Dublin has just been drained, there are two outlets, each 6 in. in diameter, there have been heavy storms of rain but no flooding. The old drains which were large and very foul have all been removed."

In Paris, in 1883, small pipes were hung on brackets in the large sewers in the quarter known as "Le Marais," in order to test the "Waring system," and gave, it is believed, general satisfaction.

A consideration of the results of actual measurement in the gaugings of flow in sewers in different parts of the world will not be out of place.

In the report of the U. S. National Board of Health, 1880, the result of gaugings of the dry weather flow in certain sewers are given, and are quoted by Colonel Waring in his work upon Sewerage.

1. A large brick sewer, 7,000 feet long, including its branches, in Madison Avenue, New York, the district being about half built upon with houses of the better class.

Result : area of greatest dry weather flow equalled " $3\frac{1}{2}$ in. x 4 in. " or nearly enough to fill a $4\frac{1}{2}$ inch pipe.

2. Sewer in Providence, R. I., 1,391 feet long. Population tributary to sewer, 267.

Result : greatest flow $\frac{7}{8}$ths of an inch in depth in a 6 inch pipe.

3. A sewer with a single short branch in Burlington, 2,790 feet long. Population tributary to sewer, 325.

Result : greatest flow 1 1-5 inch in depth in a 6 inch pipe.

4. A sewer in a closely built part of Milwaukee.

This sewer is 42 inches in diameter. The grade of the sewer at the point where the gaugings were taken was about 1 in 400. The area tributary to the sewers is about 70 acres, all nearly level, closely built, containing 500 houses, mostly dwellings, and a total population of 4,035. One hundred and thirty-two of the buildings are not connected with the sewer, the remaining 368 buildings contain a total population of 3,177, all of whom are tributary to the sewer. There are several hotels, saloons, small factories, and livery stables, so that the district is fairly representative of a very closely built city area.

The greatest flow in the main 42 inch sewer on "washing day", the greatest flow of the week, attained a a depth of 6 inches.

5. The Hospital at Ploughkeepsie with 301 persons, consuming 265 gallons of water a day each, produced a sufficient amount of sewerage at its maximum to create a stream in a 6 inch pipe 3¼ inches deep.

6. In a sewer in Ploughkeepsie, 15 inches in diameter, 2,766 feet long, with a population of 426 tributary to it. The greatest flow in a 6 inch pipe was 2¼ inches in depth.

7. The Compton Avenue sewer, St. Louis, 7 feet 3 inches diameter, accommodates 1,370 houses inhabited by 8,200 persons, in the houses are 1,391 water taps. A dam was placed across the sewer in which was built a 12 inch pipe 20 feet long, gaugings were taken simultaneously at there different points, the average of these being the assumed depth in the twenty feet of pipe ; the greatest depth of flow was less than 7 inches.

8. The Ohio Avenue sewer, St. Louis, 7 feet 3 inches in diameter, sewering 120 houses with a population of of 760, was gauged and the greatest flow found to be 1½ inches in a 6 inch pipe.

9. In George St., London, a sewer 3 feet 6 inches x 5 feet 6 inches sewered forty-four acres of closely built area ; in the bottom of this sewer a 12 inch pipe, 560 feet long, was laid through a dam at its head ; the pipe was rarely observed to be more than half full at its head : and it was found that the sum of the cross sections delivering to this half full, 12 inch pipe, was equal to the area of a circle thirty feet in diameter.

It is useless to multiply cases to show what an enormous amount of sewage, even small pipes properly laid will carry ; as however particular stress has been laid upon the smallness of the sewer, an 8 inch pipe, falling into the Douglas Street branch sewer, and laid on Yates Street from Blanchard Street westwards, a few remarks thereon will not be out of place.

The pipe provides sewerage for a total frontage, including both sides of the street, of 1,680 feet, and has a fall of 1 inch in 250, the least fall given anywhere to an 8 inch pipe.

Let us assume that each 25 feet of frontage is occupied by a house with five inhabitants, and that each person supplies five gallons an hour of sewerage, it is obvious that we have to provide for a flow of 1,680 gallons an hour ; the pipe however should not run full, and it is usual in sewerage works to calculate its capacity when running half full.

Mr. Baldwin Latham's table gives for an 8 inch pipe with a fall of 1 in 250, running half full, a velocity of 2.55 feet a second, and a discharge of 10,012 gallons an hour.

Mr. Latham's tables were however calculated prior to the exhaustive experiments of Ganguillet and Kutter, whose formulae are now universally adopted by hydraulic engineers. By the writer's Tables of Velocity and Discharge in sewers, based on Kutter's Formula, an 8 inch pipe, running half full, with a fall of one in 250 will, if well laid with the Stamford joint, have a velocity of 2.11 feet a second, and a discharge of 8,270 gallons an hour. That is to say the sewer when running half full, is of ample capacity to supply 1,654 people, which would be a population of over 24 persons for each house of 25 ft. frontage without taking into consideration the double frontage occupied by corner buildings.

The writer has no hesitation in asserting that any difficulty which may arise in keeping sewers clean, will be due to the fact that they are much larger than required for the present population ; but it has been found by experience that in sewers of the separate system it is not advisable to use a smaller pipe than 8 inches diameter, not because the sewage could not be easily carried in a smaller pipe, but because of the carelessness of the peope themselves, who allow all sorts of rubbish to pass through their house sewers into the public mains.

The first instance in which the "separate system" was introduced, was when Sir Edwin, then Mr. Chadwick introduced it in Alnwick, Northumberland, in 1849. The population was about 7,000. The water supply 150,000 gallons a day, with some 1,400 water closets in regular use. The outlet main was 18 inches diameter ; the sewers 15 inches, 12, 9, and 6 inches, and the house drains 4 inches in diameter. These sewers are still giving every satisfaction.

It has generally occured in cities, where the separate system has been introduced, that an outcry has been raised against the size of the pipes used ; this outcry has invariably been raised by those ignorant of the principles of the system, who not having studied the laws by which engineers are guided, and being unwilling or unable to learn, pretend to teach their fellow citizens that which they do not understand themselves.

It would be as reasonable to expect a man, who has not received a special training, to be competent to instruct a doctor, or a lawyer, as an engineer in his work, for to be successful in any of these professions requires years of hard study, and hard work. If this were not the case it would be quite in order for the carpenter to teach the bricklayer, and the bricklayer teach the plumber, and the plumber teach the stonemason, and the stonemason teach the machinist, and so on *ad infinitum.*

In deciding whether in a given case the "combined" or "separate" system, or a combination of both should be adopted, the engineer has to take into consideration several factors such as topography and climate.

That the "separate system" has been adopted and gives general satisfaction in a very large number of cities, is a sufficient proof to any unprejudiced mind (under the natural favorable conditions, such as exist in Victoria) of the wisdom of introducing it; not to mention its great recommendation to taxpayers, that its cost is far less than would be incurred in the construction of the "combined system."

The few brief statements following, as to the sewers now being laid may be of some interest:—

1st. The sewers of the separate system are built to carry sewage, and the water from the flush tanks with a certain proportion of roof water.

2nd. The main outlet sewer discharges nearly at the level of high spring tide, into a chamber from which it is conveyed in a submerged steel pipe out to deep water, where it is discharged beneath the surface at low spring tide level.

3rd. The sewers are tight; straight and true to grade, all changes of direction whether horizontal or vertical, are made at manholes, since it is at such points that obstructions are most likely to occur.

4th. Ample provision has been made for ventilation.

5th. By means of automatic flush tanks, the whole of the sewers can be flushed daily or at as frequent intervals as the feed may be set for.

6th. All junctions are so formed that the discharge of the subsidiary main into the larger stream is at such a level and in such a direction as to combine the two streams without checking their flow and causing eddies.

7th. Means for inspecting every portion of the sewers are provided, as also of access at frequent intervals.

It has been on more than one occasion publicly stated that where sewers have been laid in a rock trench no precautions have been taken to protect the main pipes from the effects of the blasting which will be necessary in order to make house connections. These statements are utterly without foundation ; at each anticipated junction, before the sewer was laid, the rock was excavated at the side, so that the main pipe would not be endangered by future blasting.

Such are the general principles upon which the sewerage system of Victoria is now being constructed. It matters not, however, how well and thoroughly the main and branch sewers have been designed and executed, if the house connections are faulty. The strength of a chain is that of it weakest link.

It is a well known axiom that no man has a right to do that which may imperil, or cause annoyance to his neighbour ; and one defective house sewer may form a centre for disease extending over a wide area.

Since it is as unreasonable to expect the average householder to be a competent authority on questions of sanitary science, as to expect him to be an expert in physic, surgery or law, or any other profession for which a special training is requisite, it becomes necessary to take such measures, in the interest of the whole community, as may place it out of the power of any individual to imperil the health of his fellow, either from ignorance, greed or obstinacy.

To view the matter from the lowest standpoint, to most of us loss of health means loss of income; and it has been estimated that every case of sickness represents a dead loss to the community of fifty dollars; it is beyond a doubt the duty of civic authorities to make such regulations as experience has shown are necessary both for the individual and the public safety. This has been done in many cities, where all connections with sewers, and the plumbing of all buildings have to be in accordance with certain regulations, which are enforced by a strict system of supervision by competent officers.

The advantages to the individual are obvious, whether he buys, rents or build, he knows that all the plumbing has been done under competent supervision, nor is he distracted by a multiplicity of opinions which may or may not be worth anything and of the value of which he is unable to judge, for this is not a case in which in the multitude of counsellors he will find safety.

Before closing this paper, a point which has caused considerable discussion may be referred to, viz.: The proposal to carry the house sewers from the public sewers to the street line at the time of the construction of the latter.

This proposal has been consistently urged upon the Council since prior to the inception of the work, and has only been prevented by legal difficulties, which appear to prohibit the Council from taking any steps in the matter under their present Act.

In conclusion Sir Robert Rawlinson, C. B., Mr. T. C. Keefer, C. B., and Mr. Rudolph Hering, three of the most eminent engineers of the day, have expressed themselves most distinctly in favor of the system now being constructed; against it no sanitary engineer of established reputation has ventured to offer an opinion.